Serial Number: 10/081,818

Filing Date: February 20, 2002

Title: ATOMIC LAYER DEPOSITION OF METAL OXIDE AND/OR LOW ASYMMETRICAL TUNNEL BARRIER INTERPOLY

INSULATORS

## IN THE CLAIMS

1. (Original) A floating gate transistor, comprising:

a first source/drain region and a second source/drain region separated by a channel region in a substrate;

a floating gate opposing the channel region and separated therefrom by a gate oxide;

a control gate opposing the floating gate; and

wherein the control gate is separated from the floating gate by an asymmetrical low tunnel barrier intergate insulator formed by multiple atomic layer deposition (ALD).

- 2. (Currently Amended) The floating gate transistor of claim 1, wherein the asymmetrical low tunnel barrier intergate insulator includes aluminum oxide (Al<sub>2</sub>O<sub>3</sub>), wherein the aluminum oxide has a number of small compositional ranges such that gradients can be formed by an applied electric field which produce different barrier heights at an interface with the floating gate and control gate.
- 3. (Original) The floating gate transistor of claim 1, wherein the asymmetrical low tunnel barrier intergate insulator includes an asymmetrical transition metal oxide.
- 4. (Original) The floating gate transistor of claim 3, wherein the asymmetrical transition metal oxide is selected from the group consisting of Ta<sub>2</sub>O<sub>5</sub>, TiO<sub>2</sub>, ZrO<sub>2</sub>, and Nb<sub>2</sub>O<sub>5</sub>.
- 5. (Original) The floating gate transistor of claim 1, wherein the asymmetrical low tunnel barrier intergate insulator includes an asymmetrical Perovskite oxide tunnel barrier.
- 6. (Original) The floating gate transistor of claim 5, wherein the asymmetrical Perovskite oxide tunnel barrier is selected from the group consisting of SrBi<sub>2</sub>Ta<sub>2</sub>O<sub>3</sub>, SrTiO<sub>3</sub>, PbTiO<sub>3</sub>, and PbZrO<sub>3</sub>.

Page 3

Dkt: 1303.045US1

01

Serial Number: 10/081,818

Filing Date: February 20, 2002

Title: ATOMIC LAYER DEPOSITION OF METAL OXIDE AND/OR LOW ASYMMETRICAL TUNNEL BARRIER INTERPOLY

Page 4

Dkt: 1303.045US1

INSULATORS

7. (Original) The floating gate transistor of claim 1, wherein the floating gate includes a polysilicon floating gate having a metal layer formed thereon in contact with the asymmetrical low tunnel barrier intergate insulator.

- 8. (Currently Amended) The floating gate transistor of claim 7, wherein the control gate includes a polysilicon control gate having a metal layer formed thereon in contact with the <u>asymmetrical</u> low tunnel barrier intergate insulator, wherein the metal layer includes a metal layer that has a different work function than the metal layer formed on the floating gate.
- 9. (Original) The floating gate transistor of claim 1, wherein the floating gate transistor includes an n-channel type floating gate transistor.
- 10. (Currently Amended) A vertical, non volatile memory cell, comprising:
  - a first source/drain region formed on a substrate;
  - a body region including a channel region formed on the first source/drain region;
  - a second source/drain region formed on the body region;
  - a floating gate opposing the channel region and separated therefrom by a gate oxide;
  - a control gate opposing the floating gate; and

wherein the control gate is separated from the floating gate by an asymmetrical low tunnel barrier intergate insulator, formed by atomic layer deposition (ALD) having a number of small compositional ranges [such that gradients can be formed which produce different barrier heights at an interface with the floating gate and control gate].

- 11. (Original) The vertical, non volatile memory cell of claim 10, wherein the asymmetrical low tunnel barrier intergate insulator includes an insulator selected from the group consisting of Al<sub>2</sub>O<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>, TiO<sub>2</sub>, ZrO<sub>2</sub>, Nb<sub>2</sub>O<sub>5</sub>, SrBi<sub>2</sub>Ta<sub>2</sub>O<sub>3</sub>, SrTiO<sub>3</sub>, PbTiO<sub>3</sub>, and PbZrO<sub>3</sub>.
- 12. (Original) The vertical, non volatile memory cell of claim 10, wherein the floating gate includes a polysilicon floating gate having a metal layer formed thereon in contact with the asymmetrical low tunnel barrier intergate insulator.

الحس ا

Serial Number: 10/081,818

Filing Date: February 20, 2002

Title: ATOMIC LAYER DEPOSITION OF METAL OXIDE AND/OR LOW ASYMMETRICAL TUNNEL BARRIER INTERPOLY

INSULATORS

13. (Currently Amended) The vertical, non volatile memory cell of claim 12, wherein the control gate includes a polysilicon control gate having a metal layer formed thereon in contact with the <u>asymmetrical</u> low tunnel barrier intergate insulator, wherein the metal layer includes a metal layer that has a different work function than the metal layer formed on the floating gate.

14. (Currently Amended) The vertical, non volatile memory cell of claim § 10, wherein the floating gate includes a vertical floating gate formed alongside of the body region.

- 15. (Currently Amended) The vertical, non volatile memory cell of claim  $\frac{12}{14}$ , wherein the control gate includes a vertical control gate formed alongside of the vertical floating gate.
- 16. (Currently Amended) The vertical, non volatile memory cell of claim § 10, wherein the floating gate includes a horizontally oriented floating gate formed alongside of the body region.
- 17. (Currently Amended) The vertical, non volatile memory cell of claim 44 16, wherein the control gate includes a horizontally oriented control gate formed above the horizontally oriented floating gate.
- 18. (Original) A non-volatile memory cell, comprising:
- a first source/drain region and a second source/drain region separated by a channel region in a substrate;
- a polysilicon floating gate opposing the channel region and separated therefrom by a gate oxide;
  - a first metal layer formed on the polysilicon floating gate;
- a metal oxide intergate insulator formed by atomic layer deposition on the metal layer, wherein the metal oxide intergate insulator includes an asymmetrical metal oxide having a number of small compositional ranges such that gradients can be formed in an applied electric field which produce different barrier heights at an interface with the floating gate and control gate;

المن المن

Page 5

Dkt: 1303.045US1

Page 6 Dkt: 1303.045US1

Filing Date: February 20, 2002 Title: ATOMIC LAYER DEPOSITION OF METAL OXIDE AND/OR LOW ASYMMETRICAL TUNNEL BARRIER INTERPOLY

**INSULATORS** 

a second metal layer formed on the metal oxide intergate insulator, wherein the second metal layer has a different work function from the first metal layer; and a polysilicon control gate formed on the second metal layer.

- (Original) The non-volatile memory cell of claim 18, wherein first metal layer includes a 19. parent metal for the asymmetrical metal oxide and the second metal layer includes a metal layer having a work function in the range of 2.7 eV to 5.8 eV.
- (Original) The non-volatile memory cell of claim 18, wherein the second metal layer is 20. platinum (Pt) and the metal oxide intergate insulator is selected from the group consisting of TiO<sub>2</sub>, SrTiO<sub>3</sub>, PbTiO<sub>3</sub>, and PbZrO<sub>3</sub>.
- (Original) The non-volatile memory cell of claim 18, wherein the second metal layer is 21. aluminum and the metal oxide intergate insulator is selected from the group consisting of Ta<sub>2</sub>O<sub>5</sub>, ZrO<sub>2</sub>, SrBi<sub>2</sub>Ta<sub>2</sub>O<sub>3</sub>, SrTiO<sub>3</sub>, PbTiO<sub>3</sub>, and PbZrO<sub>3</sub>.
- (Original) The non-volatile memory cell of claim 18, wherein the metal oxide intergate 22. insulator is selected from the group consisting of Al<sub>2</sub>O<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>, TiO<sub>2</sub>, ZrO<sub>2</sub>, Nb<sub>2</sub>O<sub>5</sub>, SrBi<sub>2</sub>Ta<sub>2</sub>O<sub>3</sub>, SrTiO<sub>3</sub>, PbTiO<sub>3</sub>, and PbZrO<sub>3</sub>.
- (Currently Amended) The non-volatile memory cell of claim 46 18, wherein the floating 23. gate transistor includes a vertical floating gate transistor.

24. - 84 (Previously Withdrawn)

(New) The floating gate transistor of claim 1, wherein the asymmetrical low tunnel barrier intergate insulator includes aluminum oxide having a number of small compositional ranges.

Serial Number: 10/081,818

Filing Date: February 20, 2002

Page 7 Dkt: 1303.045US1

Title: ATOMIC LAYER DEPOSITION OF METAL OXIDE AND/OR LOW ASYMMETRICAL TUNNEL BARRIER INTERPOLY

INSULATORS

(New) The floating gate transistor of claim 10, wherein the number of small compositional ranges of the aluminum oxide is adapted to form gradients in an electric filed to produce different barrier heights at an interface between the floating gate and the control gate.